Temperature dependent sex determination and hatching performance of green turtle (Chelonia mydas) at Chendor Rookery on the east coast of Peninsular Malaysia

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ABSTRACT
The green turtle (*Chelonia mydas*) is a major species of sea turtle in Malaysia. This study was conducted in 1997 and 1998 at a rookery of green turtles in Pahang. Hatching success as well as sex ratio between male and female was mainly affected by incubation temperatures. The objectives of this study are to determine the optimum temperature that could produce the best hatching performance and to obtain the suitable incubation temperature for producing the female hatching as well male of green turtle. The results showed that the temperatures between 25°C to 33.0°C are suitable for egg incubation. The temperatures between 27.2°C to 29.2°C produced more male turtle hatchlings at the Chendor rookeries, Pahang. More than 80% male hatchlings were produced at the temperatures between 27.2°C to 28.2°C. Whereas female hatchlings are dominant at the temperature above 29.5°C. Temperature between 32.0°C to 33.0°C produce 100% female hatchlings. Thus determination on incubation temperature is vital to formulate the successful hatchery management of sea turtle in Malaysia as well as in the Southeast Asian region.

INTRODUCTION

There are four species of sea turtles (*Dermochelys coriacea, Chelonia mydas*. *Eretmochelys imbricata* and *Lepidochelys olivacea*) nesting in Peninsular Malaysia. Out of four species green turtle is the major species in Malaysia as well as in the Southeast Asian region. It is well-known that the temperatures are a major factor on the success of turtle egg incubation. The temperature would affect the sex determination of turtle hatchlings as well as hatching performance. Therefore it is essential to obtain the information on the suitable temperatures of turtle hatching. The success of the clutch of eggs depends upon interaction of a number of factors, such as salinity, humidity, temperatures, gas flow, rainfall, tidal inundation, erosion and predation (Hendrickson, 1958; Ragotzie, 1959; Bustard and Greenham, 1968; Ackerman, 1974; Kreamer and Bell, 1980; Parmenter, 1980). The temperature also influences the sexual differential of *Caretta caretta* (Yntema and Mrosovsky, 1979, 1980; Reed, 1980; Limpus at al., 1983) *Chelonia mydas* (Miller and Limpus, 1981; Morreale et al., 1982; Limpus et al., 1983). Two main objectives of this study; firstly to determine suitable incubation temperatures which could produce the best hatching performance and secondly to determine the temperatures that produce the male as well as female green turtles hatchlings at Chendor rookery, Pahang. The results could promote successful hatchery management.

MATERIALS AND METHODS

The study was conducted in 1997 and 1998 at Chendor rookery, Pahang, Malaysia during two nesting seasons. The first season is from May to June, and the second season is from August to September, respectively. The sample eggs were collected from three different mothers in each sampling period. The eggs were kept in a Coleman container and cooled which ice-cubes and transported to a laboratory at MFRDMD, Kuala Terengganu for incubation. At the laboratory each clutch were divided randomly into groups of 10 eggs. Each group was set in a plastic container holding heat sterilized sand that had been collected from where the turtle normally nest. The containers were placed in constant temperature incubators such that the eggs from the clutch were set at different temperatures between 24ºC to 34ºC. The temperature of each incubator was monitored at least twice daily and minor adjustment was made as required to maintain each at its specified temperatures. Histology process was undertaken to determine the sexing of turtle hatchlings. Criteria for sexing the

hatchlings followed the methods described in Mrosovsky et al. (1984) and Dutton et al. (1985).

Results and Discussion

Table 1 shows that the hatching rate in first season at Chendor, Pahang obtained higher than 90% at the temperatures between 27°C to 32°C. Whereas 100 % hatching rate occurred at the temperatures 27°C and 30°C.

Table 2 shows that the hatching rate in the second season obtained higher than 90%, at the temperatures between 25ºC and 33ºC. This result is quite similar with the sample in first season. The temperature at 26ºC, 28ºC, 30ºC and 31ºC has produced an optimum hatchling rate (100%). Handling and transferring technique will also affect the eggs hatching. These experiments indicate that handling and transferring as well as incubation temperature were the major factor should be considered in hatchery management.

Figure 3 indicates that temperature values between 27.2 °C to 29.0°C produce more male turtle hatchlings at the Chendor rookeries, Pahang. Whereas female hatchlings are dominant at the temperature above 29.5 °C. Temperature values between 32.0 °C to 33.0°C produce 100 % female hatchlings.

Table 1: Hatchling performance in first season (May – June, 1997) of green turtles of Chendor (CH), Pahang.

Temperature	CH1(Mother - 1)		CH2 (Mother - 2)		CH3 (Mother - 3)		
(°C)	eggs incubated	% Hatching	eggs incubated	% Hatching	eggs incubated	% Hatching	% Average
24°C	10	0	10	0	10	100	33.33
25°c	10	0	10	80	10	100	60.00
26°C	10	0	10	90	10	100	63.33
27°C	10	100	10	100	10	100	100.00
28°C	10	100	10	90	10	100	96.67
29°C	10	90	10	100	10	90	93.33
30°C	10	100	10	100	10	100	100.00
31°C	10	80	10	100	10	100	93.33
32°C	10	90	10	90	10	90	90.00
33°C	10	100	10	20	10	80	36.67
34°C	10	70	10	20	0	80	56.67

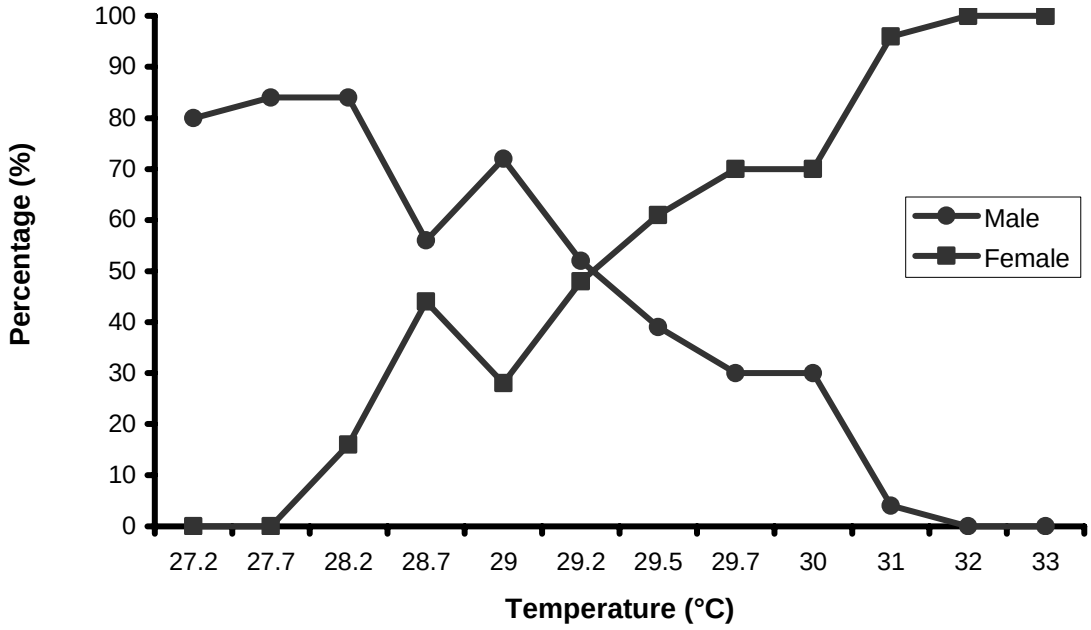
Table 2: Hatching performance in second season of green turtles in laboratory of Chendor (CH), Pahang

Temperature	CH4(Mother - 4)		CH5 (Mother - 5)		CH6 (Mother - 6)		
(°C)	eggs incubated	% Hatching	eggs incubated	% Hatching	eggs incubated	% Hatching	% Average
24°C	10	0	10	0	10	0	0.00
25°c	10	90	10	90	10	100	93.33
26°C	10	100	10	100	10	100	100.00
27°C	10	90	10	80	10	100	90.00
28°C	10	100	10	100	10	100	100.00
29°C	10	100	10	90	10	90	93.33
30°C	10	100	10	100	10	100	100.00
31°C	10	100	10	100	10	100	100.00
32°C	10	100	10	100	10	90	96.67
33°C	10	90	10	100	10	80	90.00
34°C	10	0	10	100	0	80	60.00

Table 3: Sex identification using histological protocols of green turtle's hatchlings at Chendor, at the various temperatures in 1998.

Temperature	CH-1			CH-2			CH-3			Total			%		
°C	M	F	I	M	F	I	M	F	I	M	F	I	M	F	I
27.2°C	0	0	0	9	0	1	7	0	3	16	0	4	80	0	20
27.7°C	0	0	0	9	0	0	7	0	3	16	0	3	84	0	16
28.2°C	0	0	0	10	0	0	6	3	0	16	3	0	84	16	0
28.7°C	2	3	0	6	4	0	6	4	0	14	11	0	56	44	0
29.0°C	2	3	0	10	0	0	6	4	0	18	7	0	72	28	0
29.2°C	1	4	0	7	3	0	5	5	0	13	12	0	52	48	0
29.5°C	0	0	0	5	3	0	2	8	0	7	11	0	39	61	0
29.7°C	0	0	0	0	0	0	3	7	0	3	7	0	30	70	0
30°C	0	6	0	4	6	0	3	4	0	7	16	0	30	70	0
31°C	0	6	0	1	9	0	0	10	0	1	25	0	4	96	0
32°C	0	7	0	0	10	0	0	10	0	0	20	0	0	100	0
33°C	0	5	0	0	10	0	0	6	0	0	21	0	0	100	0

Figure 3: Percentage of sex determination at various temperatures in Chendor, Pahang



M = male; F = female; I = Indeterminate

The above graph indicates that temperature values between 27.2 °C to 29.0 °C produce more male turtle

DISCUSSION

The result on incubation of the first season (May - June) showed that the average hatching percentage obtained higher than 90% at the temperatures 27ºC to 32ºC (Table 1). Whereas in the second season (August – September) the average hatching percentage obtained higher than 90% at the temperature 25ºC to 33ºC (Table 2). This occurrence might be due to handling technique of turtle eggs during the transportation from the rookery to laboratory. For instance the turtle eggs should be incubated immediately in an incubator after arriving at the laboratory. Whereby proper handling would maintain the quality of turtle eggs for hatching. Miller and Limpus (1981) reported that temperature influences the duration of incubation and the rate of the development. Low temperatures increase the duration of incubation and slow the rate of development, whereas higher temperatures decrease the duration of incubation and increase the rate of development. In conservation efforts, improper handling of eggs during movement to hatcheries may increase mortality (Limpus et al., 1979; Blank and Sawyer, 1981).

The temperatures between 31ºC to 33ºC produce 96% to 100% of female hatchlings (Table 3). Thus the particular temperatures could be considered for female hatchlings at hatchery incubation. Percentage of male hatchlings obtained 80% to 84% at the temperatures ranging from 27.2 ºC to 28.2ºC. Whereas at the temperature 27.2 ºC and 27.7ºC, 20 % and 16 % respectively are indeterminate due to poor technique on preparation of specimen slides. This result can predict that the temperature between 27.2 ºC and 27.7ºC would produce the higher percentage of male green turtle hatchlings. Under natal beach conditions, the eggs incubate at temperatures between 24ºC to 33ºC (Cardwell, 1959; Bustard, 1972; Ewert, 1979; Limpus et al., 1983). *Chelonia mydas* the incubation period lasted 94 days at 23ºC -24ºC (Ackerman and Prange, 1972) and 47 – 49 days at 32ºC (Bustard and Greenham, 1968). Within the limit of embryonic tolerance, cooler temperature produce male hatchlings at 26ºC and 28ºC for *Caretta caretta* and 26ºC for *Chelonia mydas.*

Conclusion

The average hatching performance obtained higher than 80 % at the temperature between 25ºC to 33ºC. The average temperatures between 27.2ºC to 29.2ºC produce more male green turtle hatchlings. Whereas more than 80% male hatchlings are produced at the temperature 27.2ºC to 28.2ºC. Female hatchlings are dominant at the temperature value above 29.5ºC. Temperatures between 31.0ºC to 33.0ºC produce more than 96% female hatchlings. Temperatures which are below 25ºC and above 33ºC are not suitable for eggs incubation of green turtle at Chendor rookery.

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